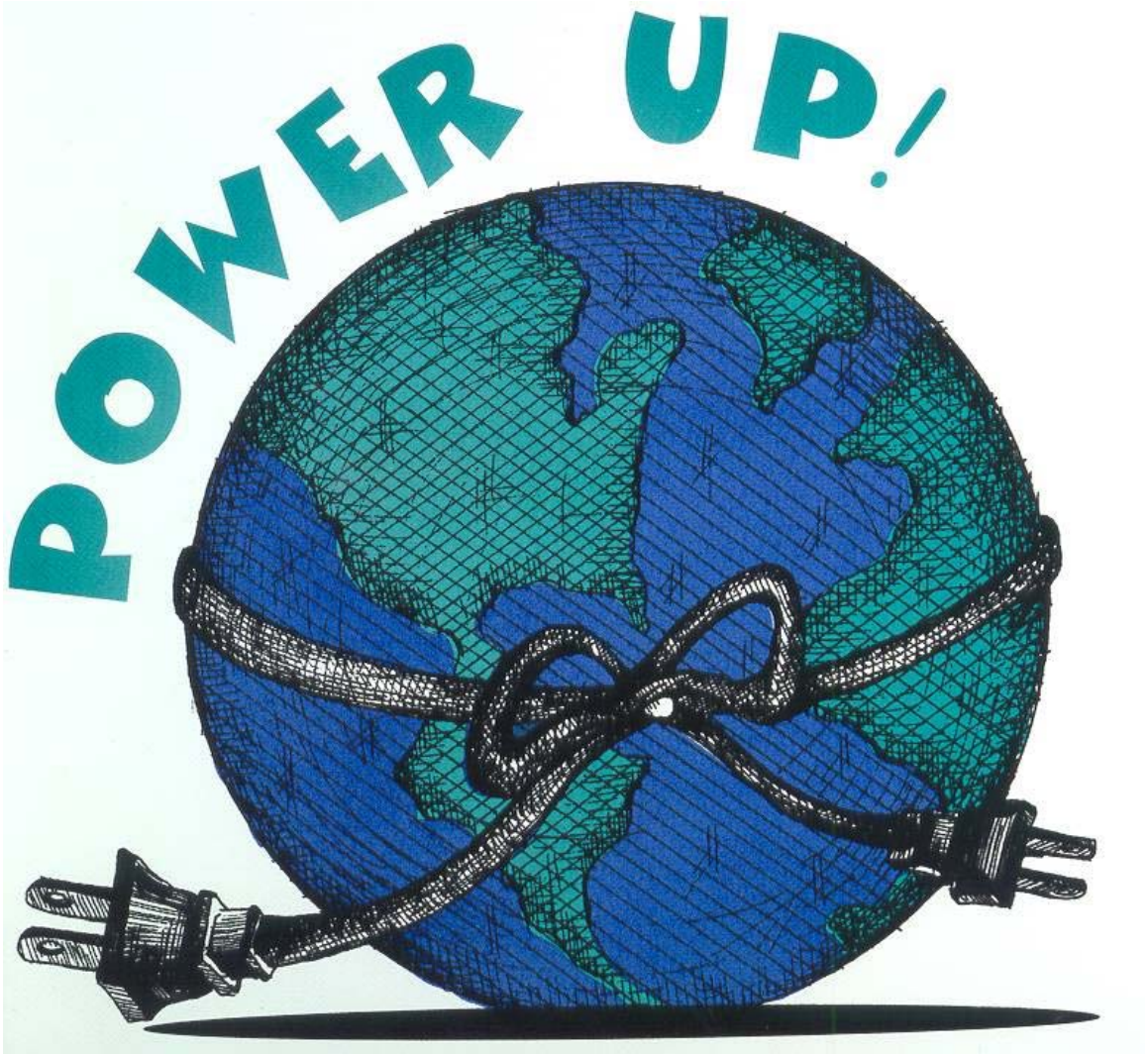
POWER UP!

Robert L. Ehrlich, Jr., Governor ! Michael S. Steele, Lt. Governor
C. Ronald Franks, Secretary

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INTRODUCTION

Energy production and use, resource conservation and environmental quality are all topics that directly affect our lives. Everyday, we live with the use of electricity and its conveniences, costs and impacts. This curriculum examines the issues of electric power; its generation (production), transmission, usage and environmental impacts in Maryland. The final unit challenges and assists students in developing a conservation ethic concerning electricity. This curriculum has been developed for Grades 4 through 8.

Curriculum Framework

The curriculum has five units:

- What is Electricity?
- How is Electricity Produced? Power Plants in Maryland
- Using Electrical Energy
- Environmental Impacts
- Energy Conservation

These units follow a sequence, beginning with the nature of electricity and ending with developing a personal action plan. After using all the units, teachers and students will have acquired an understanding of energy production and use in Maryland. Each unit can also stand on its own. For example, a class studying Maryland might use Unit II only. Each unit contains 3 to 6 activities or tasks.

Design of Learning Activities or Tasks

The activities use a variety of teacher/learning strategies: small groups cooperative learning, individual tasks, readings, lab investigations, projects and models.

Using this Curriculum

The section, “Power Plants in Maryland”, provides background information that will be useful in implementing this curriculum. This section also clarifies the role of the Maryland Power Plant Research Program. Teacher Tips providing suggestions are located prior to Unit I. The learning activities or tasks follow a general pattern of introduction, materials, procedures and discussion. Appendices include a section of teacher answer sheets (Appendix A), a list of online energy resources (Appendix B), a glossary of terms (Appendix C) and a list of suggestions for student service learning (Appendix D). A final appendix includes a list of references used in developing this curriculum.

For the most updated information (maps, data, etc.) on energy and power plants in Maryland, visit the Power Plant Research Program Online Energy Fact Book: http://esm.versar.com/pprp/factbook/plantlocations.htm or for more information on Power UP contact Elena Takaki, etakaki@dnr.state.md.us (410)260-8715.

Power Plants in Maryland

Making Choices

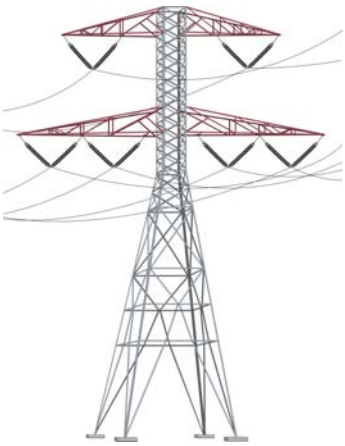
This section provides background information regarding electric power and production in Maryland. It also addresses the environmental impact of power plants. Building and operating power plants is one example of the many complex environmental issues that students will encounter in their lives. It requires finding solutions to problems that must balance a number of issues. These issues include social, economic, aesthetic, governmental, as well as environmental (ecological) issues.

Electricity is important and power plants need to be built in Maryland but it must be accomplished in a way that minimizes the affect on the environment. It is also important for teachers to help students identify players and their roles:

- government regulators,
- power plant producers,
- environmentalists and,
- consumers.

This curriculum will assist teachers and students in identifying problems and issues, understanding the different players and their positions, and resolving conflict by proposing solutions that allow for a balanced approach.

Electric Power Generation in Maryland



Power plants in Maryland, like many industrial facilities across the United States, affect the environment in various ways. For example, power plants can emit air pollutants that affect local air quality and can contribute to worldwide problems like acid rain and global warming. Some power plants in Maryland draw in large volumes of water from the Chesapeake Bay and local rivers, use it and then discharge the water, potentially affecting local fish and shellfish stocks. Ash from Maryland's coal-fired power plants is collected and disposed of at different management sites. More and more transmission lines are being built across the state as the demand for electricity grows.

All of these activities affect the local environment to some degree. Although we acknowledge the need for power plants and transmission lines, we still need to be

concerned with how power plants affect the environment. What impacts do power plants have on the environment? Are the impacts significant? What are the costs to minimize the impacts? Who makes decisions regarding power plants and their potential impacts? The Maryland Department of Natural Resources Power Plant Research Program (PPRP) investigates how power plants impact Maryland's air, water and land resources.

The Power Plant Siting Program, precursor to the current PPRP, was created by the Maryland legislature in 1971 as a result of extensive public debate regarding the potential effects on the Chesapeake Bay from the Calvert Cliffs Nuclear Power Plant. Calvert Cliffs Power Plant was a source of concern because the plant uses a cooling system that withdraws 3,500 million gallons of water per day from the Bay and discharges the water back to the Bay with a temperature elevation of about 12ºF. The magnitude and diversity of potential environmental impacts that came to light during the licensing of Calvert Cliffs Power Plant prompted the creation of PPRP. PPRP ensures that a complete evaluation and resolution of issues before future decisions are made regarding whether and where to build other generating facilities. Extensive studies of Calvert Cliffs Power Plant revealed no significant impacts on the environment.

Today, PPRP continues to assess power plant impacts to the Chesapeake Bay. In addition, PPRP's evaluations consider impacts to Maryland's air, land and human resources. They also work with utilities, agencies and citizen groups to find solutions that protect the environment and allow the continued production of electricity that meets the needs of Maryland citizens and businesses.

Fast Fact

2/3's of SO_2 and ¼ of No_x come from power plants that use fossil fuels (according to EPA 2004).

All of these areas are examined in PPRP's review of proposed power facilities, including new plants, expansions of existing plants and transmission lines. To construct any of these facilities, a company must obtain a Certificate of Public Convenience and Necessity (CPCN) from the Maryland Public Service Commission (PSC). As part of this licensing process, applicants must address a full range of environmental, engineering, socio-economic, planning, need and cost issues. PPRP manages the review of this application process, coordinating the efforts of several state agencies. The goal of the consolidated review is to ensure that adequate electricity is provided to Maryland users at a reasonable cost while minimizing the impacts on the environment and protecting Maryland's valuable natural resources.

How is Electricity Generated in Maryland?

Three types of generation technologies provide the bulk of the electricity in Maryland:

- steam turbines (both fossil-fired and nuclear-powered boilers)
- combustion turbines
- hydroelectric units

Steam turbine power plants are the most common generation technology in Maryland. A steam turbine is an enclosed rotary device in which the energy of high-temperature, high-pressure steam is converted to mechanical energy by passing through rows of radial blades attached to a central rotor. The rotational motion induced by the steam is used to generate electricity. Steam turbine plants in Maryland use either fossil fuels (coal, oil or natural gas) or nuclear fission to generate steam. Steam electric stations in Maryland burn mostly pulverized coal, reflecting the national trend during the 1970s and 1980s toward coal and away from oil as the primary fuel.

Combustion turbines are the second most common power generation technology in use in Maryland. Combustion turbines use compressors to draw air from the atmosphere and pressurize it. The compressed air is then directed to the combustor where it is mixed with fuel (oil or natural gas) and ignited. The energy of the combustion product is converted to mechanical energy by expansion in a turbine. This mechanical energy is used to drive generators that produce electricity. In Maryland, combustion turbines are used primarily to provide peak power (to help meet short-term electricity demands) when demand is highest.

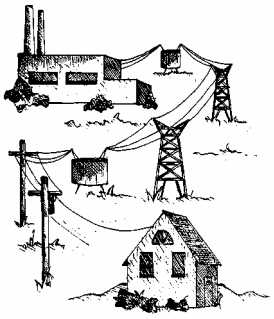
Hydroelectric power, the third major generation technology in Maryland, uses the energy of moving water to produce electricity. Potential energy in the form of stored water behind a dam is converted to kinetic energy when drawn by gravity through the dam's conduits. In this system, flowing water pushes against turbine blades to drive generators and produce electricity.

The general goals of the review process are to:

- ❖ assess the suitability of sites that utilities identify as potential locations for power plants or transmission lines.
- ❖ evaluate potential environmental impacts.
- ❖ analyze the need for new power plants or transmission lines.
- ❖ coordinate the development of recommendations.
- ❖ coordinate long range planning to meet electricity demand.

Power Industry Restructuring in Maryland

The Maryland Electric Customer Choice and Competition Act of 1999 restructured the State's electric utility industry to allow electric customers to shop for the best combination of price and services among various energy suppliers. In the past, the local electric utility operating as a franchised monopoly, supplied customers with the three main parts of electric service: generation, transmission and distribution. Now, to provide customers with choice, generation (the production of electricity) is being offered in a competitive marketplace.



To create the competitive market for electric generation in Maryland, the traditional local electric utilities are either transferring their electric generation assets to unregulated subsidiaries or selling the assets to other unaffiliated companies. The new companies that own power plants (electric generation resources) are known as electric suppliers and will remain subject to applicable environmental, socioeconomic and land-use requirements. Following the end of the multi-year transition period (2012) electric generation will no longer be subject to price regulation.

Electric suppliers can generate and sell directly to end-use customers. Power purchased from electric suppliers, regardless of source will continue to be delivered to customers by the distribution utilities. The transmission and distribution of electricity will continue to be regulated monopoly functions, and hence will be subject to price regulation.

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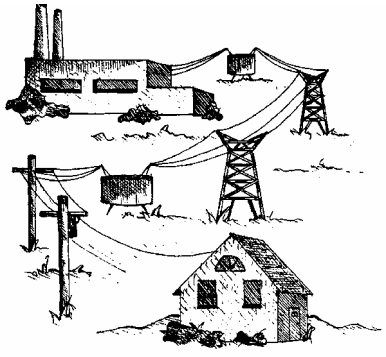
Electricity Generation and Fuel Used

Electricity generated in the State of Maryland in 2003 was through the use of energy resources such as coal (56%), nuclear (28%), natural gas (7%), oil (4%) and other miscellaneous sources including wind, solar, hydro, and the burning of municipal waste (5% cumulative).

There are 32 power plants (2 MW or greater) in Maryland, representing over 12,000 MW of operational generating capacity.



Importing and Exporting Electricity

Because electricity sales to Maryland customers are greater than the amount of electricity generated in the state, a substantial quantity of energy is imported from neighboring states.

Power Pooling

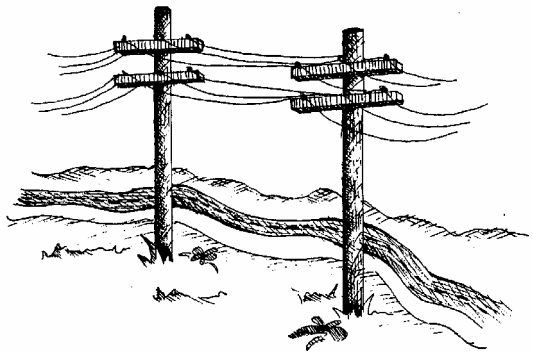
To gain the efficiency and reliability benefits of interstate and intrastate power transactions, the Maryland utilities participate in multi-utility power pools called the **Pennsylvania - New Jersey - Maryland Interconnection (PJM) Power Pool,** which also includes most of the electric utilities in Pennsylvania, New Jersey, Delaware and the District of Columbia.

The PJM pool employs an operating procedure known as **economic dispatch** to minimize fuel costs for all members. With economic dispatch, a utility system makes maximum use of its lowest operating-cost generating units (coal and nuclear plants) and only uses more expensive units (oil or gas-fired units) when the lower cost units are already running at their maximum levels. PJM implements this process by collecting plant operating data on all member plants and continuously determining the pool-wide cost of generating an additional kilowatt-hour (the incremental cost). It operates all of the members' units as a single system, in which generation is added from the most economical source available (regardless of ownership) to meet the next increment of load. These inter-company power transactions are referred to as **interchanges.** Through this system of economic dispatch, PJM gains cost savings and distributes those savings among its members.

In 2003, electric energy consumption in Maryland exceeded electric energy generation in the state by about 27%.

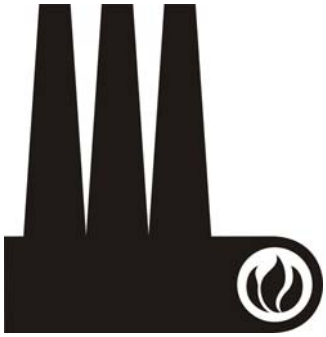
Who Uses Electricity in Maryland?

Users of electricity in Maryland are generally classified as residential, commercial, industrial and other. Overall in 2000, usage of electricity in Maryland was 39 percent residential, 43 percent commercial, 17 percent industrial and 1 percent other sales (e.g. street lighting).



Electric energy consumption in Maryland is forecasted to increase at an average annual rate of approximately 2.6 percent between 2000 and 2010. This is above Maryland's historical growth rate of about 2.0 percent during the decade of the 90's.

The factors most significantly affecting electricity demand in Maryland include growth in population; income and employment; the price of electricity; and the energy efficiencies of electricity using equipment. In addition to these factors, the mix of business activities in the state also affects electricity demand.



Resource

For more information on electricity in Maryland take a look at Power Plant Research Program's Online Energy Factbook:
http://esm.versar.com/pprp/factbook/factbook.htm

The Factbook contains information on: Utility Corporate Structures, Distribution Territories, Transmission, Maryland Power Plants and Locations, Electricity Sales, Fuel Facts, and Electricity Supply and Demand.

Teaching Tips

Unit I: What is Electricity?

1. Before beginning Task 1, you may want to have students share their prior knowledge of how electricity use was different for past generations.

2. Before beginning Unit 1, have students make a list of what they already know about electricity and what they would like to learn.

Unit II: How is Electricity Produced? *Electricity in Maryland*

1. Task 1A: Be sure to distribute Task 1A hydroelectricity information *after* the lab is completed. You may want to explain "kinetic" and "potential" energy.

2. Task 1B: Explain "revolutions per minute" (RPM). Keep the turbine at a distance from the steam; otherwise, students will not be able to read the results. (The closer the turbine is to the steam, the faster it runs.)

3. Explore in social studies why we switched toward coal and away from oil.

Unit III: Using Electricity

1. Task 2B: Ask your Principal to come into your classroom and introduce this task to the students.

Unit IV: Environmental Impacts

1. Extension Idea: Students can research other environmental impacts (negative and positive impacts of power plants on the environment.)

2. Extension Idea: Students can write to power plant companies requesting information.

Unit V: Energy Conservation

1. Task 1/Page 1: You may choose to have either the students draw their own sketch of a house on poster board or provide them with a poster of the "shell" of a house.

2. Task 1/Page 1: You may choose to have the art teacher work with students on a sketch to integrate the curriculum.

3. Task 1/Page 1: Instead of drawing arrows to household items on poster, use yarn.